A

DISQUISITIONS
Concerning the
FORCE
OF THE
HEART, &c.

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DISQUISITIONS
Concerning the
Force of the Heart,
THE
DIMENSIONS
OF THE
Coats of the Arteries,
AND THE
Circulation of the Blood.

By *JOSEPH* MORLAND, M.D.
and F.R.S.

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MVSEVM
BRITAN
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The PREFACE.

THE Structure of the Human Body and the Diſeaſes of it, are Subjects of ſo great Importance, and withal of ſo very difficult a Nature, that, I perſwade my ſelf, every Body will wiſh well to thoſe, who ſpend their time, and uſe their Diligence in theſe perplexed Enquiries. As for ſuch as never tryed the Experiment themſelves, I *think I can aſſure them, 'tis no eaſie matter to make one new Step, ſmall or great, in any Science whatever. But what thoſe Studies are, in which the greateſt Intricacies of all occur, I ſhall not in this Place, and upon this Occaſion, determine. The following Sheets contain ſome Thoughts, with which I have now and then a little entertained and pleaſed my ſelf. I do by no means conclude from thence, that they muſt be agreeable to others. Nor ſhall I mightily concern my ſelf about the Opinion the World will have* *of them, if upon the whole I find I am better qualified, as I flatter my ſelf I am, to eaſe Pain and cure Diſeaſes. This alone will be ſufficient for me.*

Had I any other Ambition, 'tis contrary to the Nature, and below the Dignity of ſuch Diſquiſitions as theſe, to endeavour to cover them from Cenſure, by mentioning the Names of any Learned Friends of mine, who have ſeen and approved them.

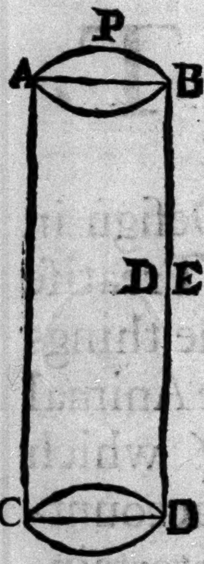
ERRATA.

PAge 20. line 15. for P read *p*. P. 22. l. 6. f. G r. D. P. 23. l. 8. after *that*, add, *will diſtend the Cylinder to a given Diſtention.* P. 25. l. 3. f. KE r. RE. Ibid. l. 6. f. 2 AE. r. 2 RE. P. 26. l. 12. f. *decreating* r. *decreaſing*. P. 28. l. ult. after *Radius* put a full Point. P. 29. l. 6. f. *n* r. N. Ibid. l. 20. f. $\frac{T}{N}$ r. $\frac{T}{R}$ P. 62. l. 14. f. *Continuance* r. *Contrivance*.

OF THE FORCE OF THE HEART.

IT being my Deſign in the enſuing Treatiſe to explain ſome things relating to the Animal Oeconomy (which I think hitherto not well accounted for) as well for the Entertainment of the Curious, as for the Improvement of the Practice of Phyſick; I ſhall firſt lay down ſome Principles and Calculations, and then deduce ſuch Concluſions as fairly ariſe from the foregoing Principles, and are ſupported by them.

PROP. I.



LET there be a Cylindrical Tube ABCD filled with a fluid Maſs, and ſuppoſe a weight perfectly preſſing and equally diffuſed over the Surface A B; I ſay every point E of the inner Surface B D is preſſed with a Weight (*n*) equal to that, with which a Point of the Surface A B is preſs'd.

Suppoſe the Surface of the Circle A B $= 1$, the Surface of the Cy-

Cylinder = 10, and ſuppoſe it compreſſible, and an infinite Number of Forces diffuſed around it, the Sum of which ſhall be = 10 × P; I ſay the Preſſure of P downwards will be in *Equilibrio* with thoſe Forces preſſing inward toward the Axis of A B C D, and this by reaſon of the Velocities of the contending Weights, which in this caſe muſt be reciprocally as the Weights, *i. e.* ſince P. 10 × P :: 1. 10; and the Velocity of P will be to the Velocity of the ſurrounding Preſſures 10 × P :: 10. 1. therefore the contending Preſſures will be in *Equilibrio*: Therefore the Preſſures from within outwards ariſing from Preſſure P on the Surface of A B C D will be = 10 × P. The ſame Reaſoning holds good, whatever other Proportion be uſed in the room of 1 to 10, and conſequently the Point E is preſs'd with $n =$ a Point of the Weight, P. *Q. E D.* Or in one Word thus:

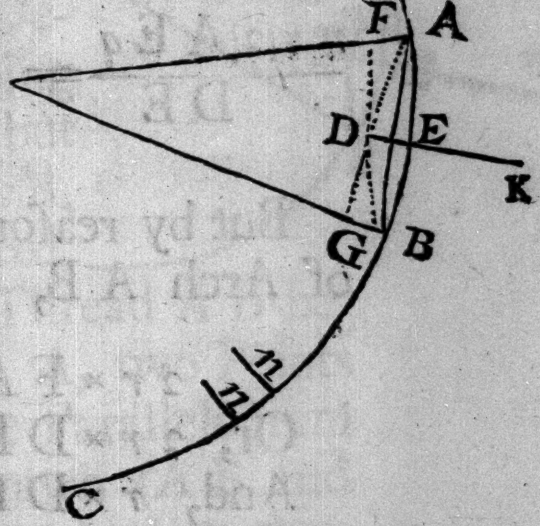
The Preſſure of P will fully reſiſt a Weight of 10 P ſurrounding the Surface preſſing inwards by reaſon of the Reciprocality of the Velocities; and this happens by reaſon of the Surface of Circle A B being to Surface of Cylinder, as 1. 10; therefore the inner Surface is preſs'd outwards with 10 × P; therefore, *&c.*

All this is confirmed by known Hydroſtatical Experiments.

* * *

PROP.

PROP. II.



LET *ac* be an Arch of a Circle preſs'd with perpendicular Forces *n*, *n*, &c. infinite in Number, let it be fix'd in A and C; I ſay 'twill be diſtended at the Point A, with a Force $= r \times n$.

Since we may conceive that a few of theſe Forces will produce the ſame Diſtention in A, as a great many: Let us take a very ſmall Arch A B, and ſuppoſe the Diſtention produced by them. Now the Preſſures on $AB = n \times AB = n \times 2\,AE$ produce D E to K, then let E K be pulled with the Forces $n \times 2\,AE$, the Diſtention will be the ſame as before; but D E being the Diagonal to A E D B. $DE . AE :: n \times 2\,AE . \frac{n \times 2\,AEq}{DE} =$ Force in A.

But by reaſon of the Smallneſs of Arch A B,

$$2r \times FA = FGq$$

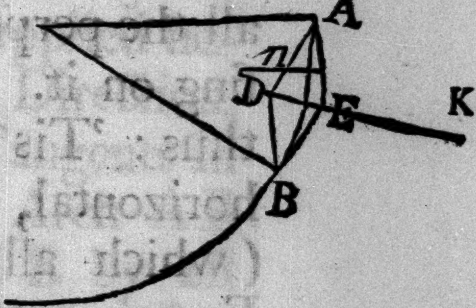
Or, $2r \times DE = 4\,AEq$

And, $r \times DE = 2\,AEq$

$$r = \frac{2\,AEq}{DE}$$

Therefore, $\frac{n \times 2\,AEq}{DE} = rn =$ Force in A. *Q E D.*

SCHOLIUM.

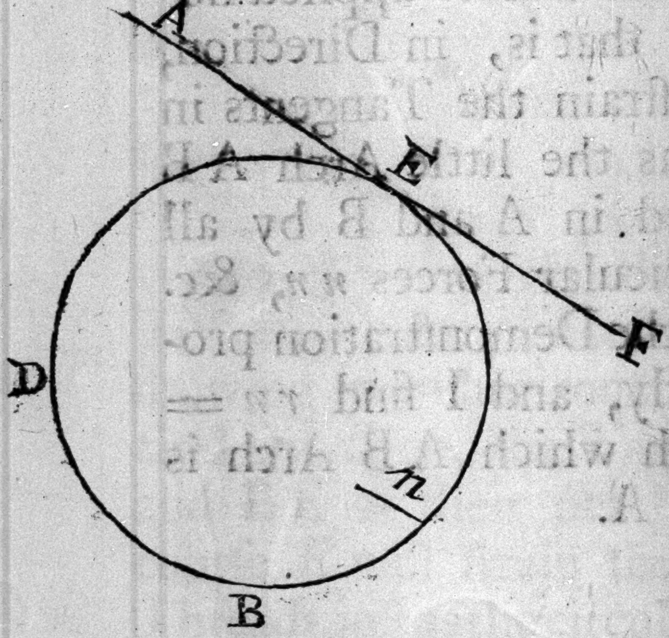


I can't ſee any Defect in the foregoing Demonſtration, but that I have not prov'd, but taken for granted, that the circular Thread A B being fix'd in B and A, two Points very near, and the Parallelogram A D B E being drawn (A B and B E being Tangents) that then the Sum of the perpendicular Forces preſſing on A B being $n \times$ A B, or (which is all one in this caſe of A B being very ſmall) $n \times 2$ A E, that then the Forces $n \times 2$ A E being applied to the point of Concourſe of the Tangents, and drawing in the Direction of the Diagonal D E or E K, will ſtrain the Tangent Threads A E and B E in A and B, exactly as the circular Thread A B was ſtrained before by the Preſſure of all the perpendicular Forces preſſing on it. Now this is proved thus: 'Tis allowed that all the horizontal, and vertical Forces (which all thoſe perpendicular Forces preſſing on the circular Thread A B may be reſolved into) drawing in an horizontal and vertical Direction, the Tangents A E and B E at their point of Concourſe E will ſtrain the Tangent Threads, juſt as the circular Thread A B was ſtrained in A and B by the perpendicular Forces *n n*, &c. preſſing on it. But now in the caſe of A and B being very near, all the perpendicular Forces between A and B muſt be conſidered as parallel, and therefore all as horizontal; therefore there are no vertical Forces to be applied to E the Concourſe of the Tangents, and conſequently all the horizontal Forces applied horizontally, that is, in Direction, E K will ſtrain the Tangents in A and B, as the little Arch A B was ſtrained in A and B by all its perpendicular Forces *n n*, &c. Therefore the Demonſtration proceeds rightly, and I find $rn =$ Force, with which A B Arch is ſtrained in A.

* * *

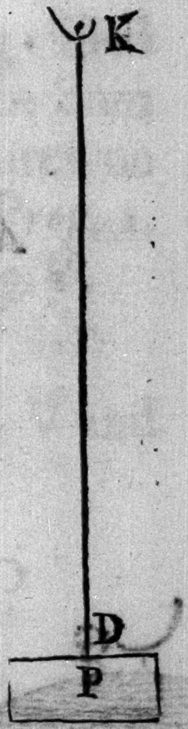
PROP.

PROP. III.



LET there be a circular Elaſtick Thread diſtended to a given Degree, by a Fluid preſſing perpendicularly every where on the inner part of the Circumference, E B D n being the Force puſhing on any one Point, and r = *Radius*; rn is = to the abſolute Force with which any Point E is diſtended in the Direction of the Tangent A E F by *Prop.* 2. let $rn = p$. Now the

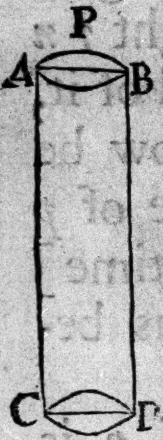
Prop. is this: If $rn = p$. I ſay let the Thread E *n* D be cut and hung at K lengthwiſe, with the Weight $r\,n$ or p faſtned at the end of it, *i. e.* at D, it will now be diſtended [the Force of p acting for a ſhort time] to the ſame Degree as before.

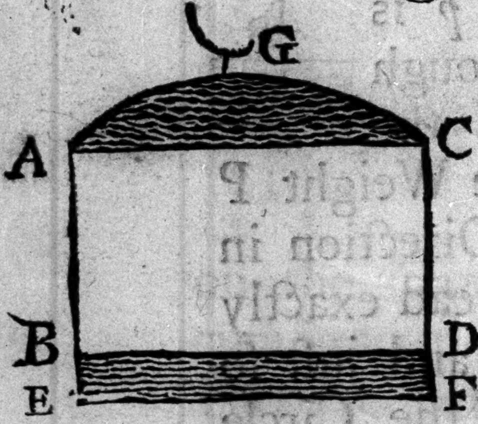


For the Force of p is equally diffuſed through the whole length of the Line K D, *i. e.* the Weight P acts in a rectilinear Direction in every point of the Thread exactly with the ſame Force, and juſt ſo it did in diſtending the Circle E B D; therefore the Diſtentions in both Caſes will be equal. *Q E D.*

PROP.

PROP. IV.





Let there be a Cylindrical Tube ABCD apt to ſtretch, let it be cut in ſome Line BD, ſo that being opened 'twill become the Parallelogram ACBD. Let it be now in this Form faſtened to ſome fixed Body, G A C, and a Weight BDEF be equally applied to the Baſe BD, let this Weight be called V.

Let r = Rad. of Circle AB,
c = the Circumference.

Let the Area of Circle AB be to Surface of the Cylinder :: 1 . m.

then [the Cylinder being filled with a Fluid] $m \times p$ = the Sum of the perpendicular Preſſures on the internal Surface by *Prop.* 1. and by *Prop.* 3. $c.r. :: m \times p.V.$

Therefore $\frac{r \times m \times p}{c} = V$ and $\frac{V \times c}{r \times m} = p.$

That is, if V be given; the Circumference of Circle A B divided by the Rectangle of the *Radius* into m is a Quantity, which multiplied into the Weight V, gives p the Weight preſſing on Circle A B, which will ſo diſtend the Tube as V does the Parallelogram, which is the Fourth Propoſition.

Or thus: If n be a Point, the Weight p and l = length of the Cylinder. Then,

$$m \times p = c\,l\,n.$$

And, $V = r\,l\,n$, by *Prop.* 3.

Therefore, $c . r :: m \times p . V$.

Therefore, $\frac{V \times c}{rm} = p$.

COROLLARY I.

Hence, $\frac{V \times c}{2\,l} = p$, for

$\frac{rc}{2}\ c\,l :: 1 . m$ by Hypotheſis.

And, $\frac{mr}{2} = l$ and $mr = 2\,l$, therefore,

$$\frac{V \times c}{mr} = \frac{V \times c}{2\,l} = p. \text{ QED.}$$

So that by experiment the Weight V diſtending to a given Degree, the Parallelogram A B C D either of theſe Expreſſions will give P the Weight, which muſt preſs on Circle A B, ſo to diſtend the Cylinder A B C D into which the Parallelogram is now converted. And thus we have propoſed a Calculation of ſuch a Force as that of the Heart is, impreſs'd on the Mouth of the Aorta coming out of the Heart; and by that impreſſed Force diſtending the cylindrical or conical Tubes of the Arteries, to which I ſhall next apply my ſelf, after I have only mentioned a few more Corollaries.

COROLLARY II.

When the Length of the Cylinder is equal to a Quadrant of the Circle, then P muſt be equal to V to produce equal Diſtentions, one by its Preſſure, the other by being hung, as in the foregoing Propoſition.

COROLLARY III.

If the Length of the Cylinder be equal to half the Radius, and the preſſing Weight be to the hanging Weight as the Circumference to the Diameter, the Diſtention will be equal in both caſes, *i. e.* if the Surface of the Cylinder be equal to the Area of the Circle.

COROLLARY IV.

When the Length of the Cylinder is equal to the Diameter of the Circle, then the preſſing Weight muſt be to the hung Weight, as the Area of the Circle is to the circumſcribing Square, that the Diſtentions may be equal in both Caſes.

COROLLARY V.

When the Length of the Cylinder is equal to $\frac{3}{8}$ of the Circumference of the Circle, then the preſſing Weight muſt be to the hung Weight, as the Sphere to the circumſcribing Cylinder, that the Diſtentions produced both ways may be equal.

In the laſt Place.

It follows from hence, that Cylinders of different Lengths, if the Circle at the Baſis be the ſame, will be equally diſtended by the ſame preſſing Weight P, on the Surface of the Fluid A B.

N. B. In the foregoing Corollaries, the Length of the Cylinder, mentioned in them, muſt be doubled, that the Conſequences may be true.

PROP. V. Problem.

Fig. 1.

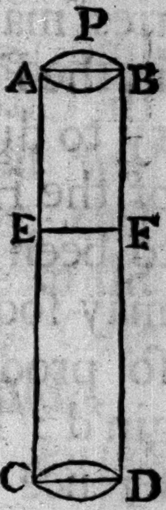
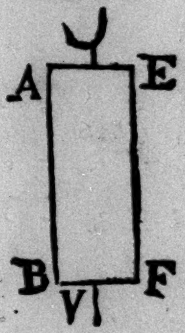


Fig. 2.



AN Elaſtick Canal ABCD being given, and its Diſtention being given, produced by a preſſing Weight P on the Surface of a Fluid, contain'd in it; to determine what that Weight is: Cut off by a Section parallel to the Baſe, the Annulus AEBF, turn it into Parallelogram by a Section perpendicular to the Circumference of the Circle AB, apply a Weight V to BF [*Fig.* 2.] that ſhall ſo diſtend it as the Weight P did the Cylinder (*c* being the Circumference of Circle AB) $\frac{c \times V}{2AE} =$ P. *q e i.*

COROLLARY

Hence the Length of the Arteries makes very little Alteration in the Force of the Heart, neceſſary to diſtend them and the Force of the Heart, which hath hitherto been ſuppoſed to be immenſe, may ſoon be found far from being ſo prodigious as has been imagin'd: For ſuppoſe the Circumference of the Aorta coming out of the Heart, to be $c = 1$ Inch, and that by Experiment you had found a Pound Weight [P] will diſtend a ſmall Cylinder of the Aorta of an Inch in Length, ſo divided as in *Prop.* 5. to the ſame Degree as the Force of the Heart does.

Then as before $\frac{c \times p}{2 \times 1} = P$, *i. e.* if the Circumference were an Inch $\frac{1 \times p}{2 \times 1} = \frac{p}{2} = P$. *i. e.* the Force of a Half of a Pound Weight will diſtend a Cylindrick Artery, tho' it were many Inches long, to the ſame Degree, that in this Caſe the Force of the Heart would.

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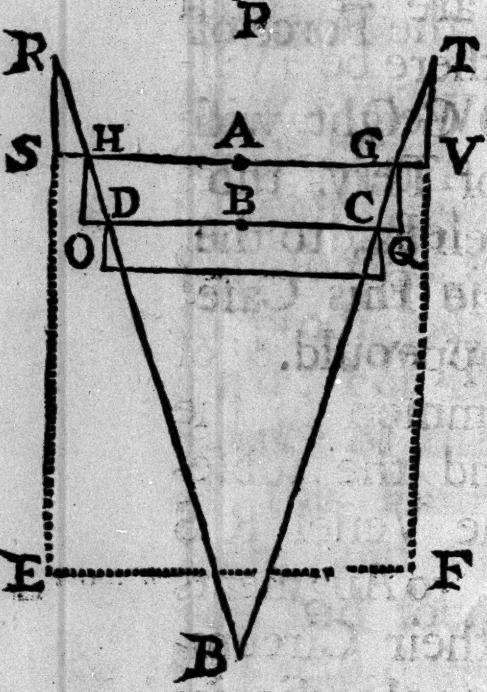
PROP. IV. Problem.



LET there be given RBT a Conical Cavity, whoſe containing Sides H and G are of thickneſſes proportionable to the Radii H A and D B: Let it be fill'd with a Fluid Maſs, and the Surface of that Maſs be preſs'd with a Weight P; ſo that the parallel Circles, of which the Cavity conſiſts, be diſtended to Augments proportionable to the Circumferences of thoſe Circles, to determine what that Weight P is.

LEM-

LEMMA.

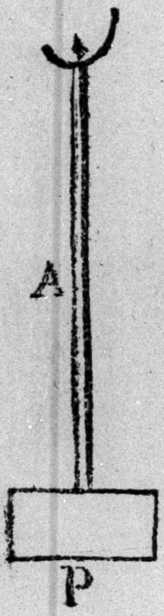
Let there be a Cylinder R T E F, whoſe Sides are of equal Thickneſs, and let there be 2 Veſſels R S T V, H O G Q, whoſe Sides R S, H O are of Thickneſſes proportionable to their Radii H A, D B, I ſay the ſame Force that will diſtend the upper Part of both, which is common to the ſame Diſtention, and the ſubſequent Parts of the Veſſel R S T V, H O G Q, *&c.* to Augments proportionable to their Circumferences. For when the Forces are as Thickneſſes, the Diſtentions will be as the Length, or as the Circumferences; but here [*n* being the ſame] the Forces are as *r n*, *i. e.* as the Thickneſs. Therefore, *&c.*

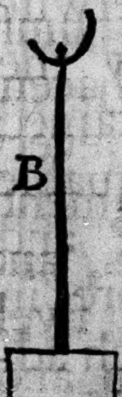
Now then the Cone conſiſts of Sides, whoſe Thickneſſes are proportional to their reſpective Radii. The Diſtention of any Cylindrula H G D C of the Cone, will be to the Diſtention of the correſponding Cylindrula in a given Ratio, or as the Axis of the Cone to the Side of the Triangle *per* Axem: Therefore, if I know by tryal how much any circular Filament of the Cone is diſtended, I know alſo how much more the circumſcribing Cylindrula will be diſtended (by this Ratio which is given.) This being known of one, is known of all, *i.e.* I know how much P (be it what it will) will diſtend the Cylinder R T E F; that being known, I cut off from the upper Orifice of Cone R T B a ſmall circular Filament, and find by tryal, what

Weight will diſtend it to the Degree found as before; multiply this Weight into K E, and call it V (*c* repreſenting the Circumference of Circle, whoſe Radius is as) $\frac{c \times V}{2AE} = P$, the Weight that diſtends the Cone.

To the firſt given Diſtention I have hinted ſomething before, and muſt here take notice, that the Thickneſs of the Coats of the Arteries is nearly as the Diameter of the adjacent Circle, otherwiſe the Arteries would not, by the Preſſure of the Fluid contained in them, acquire that equable Diſtention which they do, and not tumifie and ſwell more in one part than another; which admirable Frame and Mechaniſm of them, I ſhall next demonſtrate. This is that which Mr. *de Litre*, an ingenious Member of the Royal Academy at *Paris*, looks upon as an unfathomable Myſtery; and *Bellini*, when he conſiders it, thinks he has as good as ſolved the Difficulty, by falling into one of his uſual Fits of Wonder and Exclamation.

PROP. VII. Problem.





TO determine what muſt be the decreating Ratio of the Thickneſs of the Coats of the Arteries, that in their Diſtention they may not ſwell out in one part more than another; I take it to be evident, that if there be Two Filaments A and B, of different Thickneſſes and Lengths, A and B will then be diſtended to Augments proportional to their Lengths, if the Weights P and *p*, which ſtretch them, are as their Thickneſſes: But in the Caſe of the Arteries (retaining the ſame Symbols, and T and *t* repreſenting two different Thickneſſes.)

P. *p* :: R*n*, *rn* :: T. *t*, and the perpendicular puſhes *n* and *n* I ſuppoſe equal; therefore R. *r* :: T. *t*, that is, the Thickneſs of the Coats of the Arteries muſt decreaſe, as the Radii of adjacent Circles, that ſo they may every where be diſtended to Augments proportional to thoſe Circles, and not become tumid, and ſwell out more in one part than another.

Hence it is, that if an Artery be wounded with a Lancet in bleeding, or any other way, the Coats of the Arteries are weakened or made thinner, the continual Strokes of the arterial Fluid muſt of neceſſity diſtend that part to an unuſual Bigneſs, as it happens in Aneuriſms; for then the Thickneſs of the Coat loſes its Proportion, and together with that its proportional and equable Diſtention as (in this Propoſition) does plainly appear. This is, as I ſaid on Suppoſition, that the perpendicular Stroke of the Fluid is equal, or nearly equal, every where: But leſt it ſhould be ſaid that this Propoſition is not univerſal enough, I ſhall give the Thickneſs of the Coats of the Arteries, let the perpendicular Stroke be as the Square of the correſpondent Radius then ſince as before.

$RN.\,rn :: T.\,t.$ and $N.\,n ::$ $RR.\,rr$ by Hypotheſis. Then

$R^3.\,r^3 :: T.\,t$, i. e. the Thickneſſes are as the Cubes of the Radii, if this Caſe be poſſible: And thus, whatever be the Ratio n to n, you may determine the Thickneſs of the Coats of the Arteries requiſite to their equable Diſtention: Nay farther, ſince $RN.\,rn :: T.\,t.$ and you may meaſure the Thickneſs of the Arteries in different parts of them, and take their reſpective Radii. Having done this, you may now find what the reſpective perpendicular Strokes are for,

$T \times rn = t \times RN.$ and therefore,

$\frac{T}{N}.\,\frac{t}{r} :: N.\,n.$ that is, the Ratio of the perpendicular Strokes is compounded of the direct Ratio

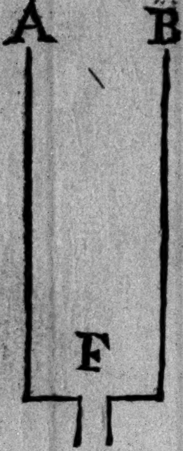
tio of the Thickneſſes, and the inverſe Ratio of the Radii of them.

As I have ſaid, theſe things may ſeem ſtrange, and upon tryal the Force of the Heart will be found ſo much leſs than what the famous *Borelli* has computed it to be, that ſome will, upon that very ſcore, reject my Method of Calculation. All that I deſire of them, is, that they would diſcover the Faults of it; for I look upon this as a very difficult Enquiry: Nor did I ever hear of any one [ſince the World began] that pretended to have given this dark, and intricate Subject any light but *Borelli*, if he did; for I rather think, that thoſe Calculations of his, concerning the Force of the Heart, were his firſt imperfect Eſſays, far from having received his laſt Hand and Approbation.

bation. But leſt any one ſhould fancy the Force of the Heart to be equivalent to ſo vaſt a Weight as that of 3000 Pounds, I ſhall only ſuppoſe it but equal to an 100, and then ſolve the following Problem.

PROP. VIII. Problem.

WHAT muſt the Velocity of the Blood be in the Orifice of the Aorta, that its Shock may be equivalent to 100 Pounds?



If the Veſſel A B be 16 Feet high, and the Foramen F be an Area of half an Inch, the Veſſel being full, the Water at F will be preſs'd out with a Velocity, which will carry it up to B, that is, 16 Feet; that is, it has the Velocity which it would acquire in falling downwards 16 Feet, and in this Caſe moving with the Velocity, which it has acquired, it would deſcribe in the ſame time double the Space it did in falling, that is, it has a Velocity which continuing the ſame, will carry it 32 Feet in a Second of Time. Now if you ſuppoſe 12 Cubick Feet of Water to weigh 840*l.* at that rate 16 Cubick Feet will weigh 1120*l.* *i.e.* a Column of Water, whoſe Baſe is a ſquare Foot, or 144 Inches, and whoſe Height is 16 Feet. Therefore a Column of Water, whoſe Baſe is ½ an Inch, and Height 16 Feet, will weigh 3 *l.* 8. *i. e.* 3 Pounds 8 Tenths; for eaſe of the Calculation, ſay 4 Pounds: This is the Weight it would ſuſtain by the Force of running out at F, or its Shock is equal to 4 Pounds. Now ſince the Shocks of Water running out of the ſame Foramen (or the Weights they are equivalent to) are as the Squares of the Velocities of the running Water; it follows, that if F = the Orifice of the *Aorta*, and the Shock of the running Blood be equivalent to an 100 *l.* that the Blood muſt go 160 Feet in the ſixtieth Part of a Minute, that its Shock may be equivalent to an 100 *l. i. e.* 9600 Feet in a Minute, which is at the rate of about 2 Miles in a Minute. I leave any one to judge whether ſo much as this have any Probability, and what that incredible Velocity muſt be which ſhall make its Force equal to 3000*l*? But from what has been demonſtrated a much ſmaller Force is ſufficient to diſtend the Arteries, and conſequently we have no occaſion for ſuch a prodigious Velocity, as is made neceſſary by giving the Heart ſuch an immenſe Force: Thus much of the Method I would propoſe, whereby to calculate the Force of the Heart. I ſhall ſay ſomething briefly in the next Place concerning

The Circulation of the Blood.

And here taking for granted what is commonly known concerning it;

1. I ſhall demonſtrate the rigid Neceſſity of the *Auricles* thus: The *Auricle* receives a Quantity of Blood from the Stream of the Veins; by that time it hath received it from the Veins, they muſt be ſupplied with the ſame Quantity from the Arteries, *i. e.* the Heart and Arteries muſt both contract during the Time of the Filling of the *Auricle*. Hence it follows, the *Ventricle* cannot receive the returning Blood without the *Auricle*: For ſuppoſe the returning Blood ran immediately into the *Ventricle*, by that time it has received it, there muſt be a ſupply in the Veins, that is, the Heart and Arteries muſt contract during the Time of its Influx, that is, the Heart muſt contract and dilate at the ſame Time. But this is abſurd; therefore there

is a rigid Neceſſity of the *Auricles*, which was to be demonſtrated. Hence follows a Corollary, which might lead us into the Knowledge of the Mechaniſm of the *Valves*. The Corollary is this, That the Contraction of the Heart laſts till the Arteries have contracted; for till both theſe Contractions are finiſh'd, the *Auricle* is not full: Therefore the *Ventricle* not opening, till the *Auricle* is full, it holds its Contraction, till the Arteries have contracted: For only by this Method is it, that the Venal Blood is exactly in the ſame Condition, as it was before it filled the *Auricle*. But for ſome Reaſons I ſhall forbear to enlarge on this Head at preſent.

2. I ſhall make ſome Enquiry into that ſteddy Principle of Nature, by which the alternate Con-

traction and Dilatation of the *Auricles* and *Ventricles* is ſecured. I ſuſpect the left *Auricle* to be that part where the tender Springs of this compound Muſcle of the Heart conſiſting of *Auricles*, and both the *Ventricles* are chiefly planted. And that the Arrival of the Blood touching thoſe Springs, do's by one and the ſame Touch of the ſame tender Extremities of the *Nerves*, by means of Plexus and Communications, give Motion to all the *Nerves* that ſerve both the *Auricles*, and both the *Ventricles*. To proceed, it ſeems to me neceſſary that there ſhould be an eſtabliſh'd Quantity of Blood, which, till it has received, the left *Auricle* continues in a State of *Dilatation*, and upon which it contracts as ſoon as it has received it; and the ſame

Touch of the ſame *Nerves* gives *Dilatation* to both the *Auricles*, and produces the *Contraction* of the *Ventricles*, and *è contra.* Without ſuch a Principle as this, theſe alternate Motions could never be ſecured. For I pray, in the Inſtance of two Weights, one always deſcending while the other aſcends, how will you ſecure this Contrariety of their Motions, unleſs the very ſame Force that makes the one aſcend, ſhall juſt ſo long make the other deſcend. As for thoſe Plexus's and Communications which I have mentioned, the Reader may conſult Dr. *Lower de Corde*, and inſpect that Scheme of Nerves there deſcribed, which ſerve the Heart: One Remark I deſire him to make, and that is, how numerous and crowded the Nerves lie about the left *Auricle*.

3. The Circulation of the Blood in the *Fœtus*, does not a little favour this Suſpicion.

The Maternal Blood is allowed by Anatomiſts, to be derived to the *Fœtus* by the *Umbilical Vein*, having firſt paſt through the *Placenta*.

This Vein conveys the Blood through the *Vena Porta* into the *Ductus Venoſus*, that conveys it into the *Cava*, and ſo immediately to the Heart: This Blood aſcends the *Cava*, rebounds againſt an Eminence or Protuberance, called the *Iſthmus* of the *Cava*, paſſes through the *Foramen Ovale*, which is there ſituated, where the inferior Trunk of the *Cava* lies contiguous to the Pulmonary Vein; from thence it paſſes into the left *Auricle* and *Ventricle*, which by its Contraction puſhes it into the

Aorta: As for the right *Ventricle*, that is ſaid to be ſupplied by the *Vena Cava deſcendens*.

There is one material Point worthy of Conſideration in this Subject, and that is the firſt Entrance of the Maternal Blood into the *Fœtus*; which I am apt to think gives Light to the Reaſon of the Situation of the *Ductus Venoſus*, and diſcovers all the Channels of the Circulation of the Blood, to lie in a folded and complicated State, as well as thoſe of the Lungs. I conceive then, that at the firſt Entrance of the Blood into the *Fœtus*, that the great Author of Nature has this Deſign in view, to convey as nimbly and ſecurely as poſſibly the Blood to the Heart of the *Fœtus*, and particularly to the left *Auricle*, in ſubſerviency to a ſecond Deſign;

which is to unfold the compreſſed and complicated *Blood Veſſels*, by the Pulſation of the Heart, which can't begin till the Arrival of the Blood at both the *Auricles*, and particularly at the left through the *Foramen Ovale*, if that *Auricle* ſhould have the Uſe I have aſſigned it. Agreeable to theſe Deſigns is the Situation of the *Ductus Venoſus* annexed to the *Vena Porta*, the Blood coming from the *Vena Umbilicalis*, being denied a Paſſage by the complicated Veſſels of the *Spleen Pancreas* and *Inteſtins* on one Hand, and thoſe of the *Liver* on the other, which lie like Mountains on each ſide of the *Porta*, muſt puſh forward through the *Ductus Venoſus* to the Heart, with all poſſible Expedition, being at the ſame time repuls'd by the *Iſthmus* of the *Cava*; which at that time I ſuppoſe yet unfolded. Thus is the Blood turned all upon the Heart, part of which at the ſame time enters the *right Auricle*, part paſſes through the *Foramen Ovale* to the *left*. And this I conceive to be the firſt Moment of the *Pulſation of the Heart*, which would have had no beginning without the Arrival of the Blood at the left *Auricle*. If this be the real State of the Caſe, why ſhould we be in any doubt about the primary Uſe of the *Foramen Ovale*? Now then both *Auricles* and *Ventricles* being rightly ſet to work together, the Explication of the *Blood Veſſels* is ſteddily purſued. The Blood from the right *Ventricle* paſſes through the *Canalis Botalli* into the *Aorta*, which, by its Contraction, ſends forward the

Blood to unfold the Arteries: On the other Hand, the Blood in its Paſſage through the *Porta* and *Cava* gradually unfolds the Syſtem of the Veins, till at laſt, having explicated both Veins and Arteries, and their Capillaries, a regular Circulation of the Blood enſues. And this I take to be the Time of *Quickening*, when the *Fœtus* may be ſaid to begin to live. The ſame Thing is done in the Lungs; but there, by Reaſon of the cloſe Compreſſion of their Subſtance, the Work goes on ſlower, but at laſt is finiſh'd too, and this is the Time of *Birth*: For when once the Blood circulates through the Lungs, Reſpiration becomes neceſſary, and not till then. And as the Blood will no longer circulate through the Lungs than we reſpire Air; ſo when once they are filled with Blood, the *Fœtus* is under an abſolute Neceſſity of *Reſpiration*, and ſtruggles to be born.

4. I ſhall in the next Place ſhew how it comes to paſs, that the due Proportions of Blood are maintained in the Arteries and the Veins. Suppoſe then by any means, that the Quantity of Blood is not what it ſhould be in the Veins; it muſt follow, that they will contract about their leſſened Quantity, and that the next Contraction of the Arteries will produce a ſlower Stream in the Veins, their Coats being now more lax, and not in ſo great a Degree of Tenſion, as before: Part of that Force which ſends the Blood forward in them, is loſt in their Diſtention, and thus a ſlower Stream is produced. Therefore,

fore, during the Time of the Filling of the left *Auricle*, there will enter a leſs Quantity than uſual into the right *Auricle*. This leſs Quantity, by the common Contraction of the *Ventricle*, is ſent into the Lungs; and now there again the Current is ſlower than it was, and conſequently the left *Auricle* will be a longer Time than uſual in its *Dilatation*, the left *Ventricle* at the ſame Time continues a longer Time than uſual in *Contraction*: This follows from the allowed Contrariety of their Motions. Now I ſuppoſe, that the longer it continues in a State of Contraction, the greater the *Contraction* will be; and that imitating the Motion of vibrating Bodies, the greater its ſubſequent *Dilatation*, and the ſtronger the enſuing *Contraction*, and the greater the Diſtention of the Arterial Veſſels. But they returning to thoſe Dimenſions which they had before by this laſt puſh of the Blood, muſt ſend a greater Quantity than they did before into the Veins, and thus theſe Engines of Circulation rectifie this Diſorder, when there is not a due Proportion of Blood in the Veins.

So that, at what time ſoever the Blood ſhall move too ſlow, the Machine being in good order, the above-mentioned Method will correct that Error. If it move too faſt; then again, the Converſe of that Method will rectifie this Irregularity. And I have ſometimes thought, that the Reaſon of the Wideneſs of the *right Ventricle*, might be to render it capable of a great Latitude of Vibrations from Dilatation to Contraction, in order to correct the accidental Errors which may happen in the Circulation of the Blood through the Lungs. But theſe Matters well deſerve, and require to be conſidered with great Attention.

5. I ſhall conſider the

PULSES,

and give the true Reaſon of moſt of the Variations that happen in them. For Inſtance;

1. Let the Pulſe be *quick* and *ſtrong*. Then both Heart and Arteries acquire a great Strength. The Heart is ſtrong enough to diſtend a very Elaſtick Artery. And this is the Pulſe of a Fever.

2. Let it be *ſtrong* and *ſlow*; which is an *healthy* Pulſe. Both Heart and Arteries are ſtrong;

but the Elaſticity of the Arteries do's not bear the ſame Proportion to the Strength of the Heart, as in a Fever.

3. Let it be *quick* and *low*. If the Heart grow weaker in Proportion than the Elaſticity of the Arteries, then the Arteries will have a ſmall Diſtention, but a quick Return; which is the Caſe of Perſons worn out in a Fever, they have a Pulſe *quick* and *low*.

4. Let the Pulſe be *ſlow* and *weak*. Then the Heart can diſtend a weakened Artery but a little, and that can contract again but ſlowly, by reaſon of its weakened Elaſticity.

These, and ſuch like Remarks conſidered together, with the Alteration of the Qualities of the Blood, upon which the Quantity, that the *left Auricle* ſhall receive, may depend; and well weighed, I hope, may prove uſeful, at leaſt, to my ſelf, in judging of Diſtempers by that great *Criterion* of Phyſicians, *the Pulſes*: And from them to be directed to diſcover the Seat of Diſeaſes, particularly when they are ſituated in the *ſolid Parts* and *Nerves*, when in the Maſs of *Blood* and *Fluids*.

5. Let the Pulſe *almoſt* or *entirely ceaſe*. The Conſequence muſt be this, which happens in Faintings: The Arteries contract without Reſiſtance, throw a great Quantity of Blood into the Veins, and Perſons look pale or livid; and hence it is that dying Perſons have their Faces lead-coloured and pale, which *Hippocrates* has enumerated among the certain

Symptoms of approaching Death.

In the Sixth Place, I ſhall deſcribe the Operations of the *Engines* of the Circulation of the Blood. And this I ſhall do in a Propoſition or two.

PROP. I.

During the Time of the Contraction of the Arteries, the Auricle *receives its Quantity of Blood, contracts, and the* Ventricle *begins to contract.* I prove it thus:

The *Auricle* opens upon the Contraction of the *Ventricle.* The Stream of the Veins is always running. Therefore it begins to fill as ſoon as it opens, that is, upon the Contraction of the *Ventricle.* The *Ventricle* holds its Contraction till the Arteries have contracted, ed, that is, till the *Auricle* is full; but the time ſpent in the Contraction of the Arteries is till they are ſtruck again by the Contraction of the *Ventricle*, that is, till the *Auricle* is full, contracts; and the *Ventricle* contracts. Therefore the time of the Contraction of the Arteries is equal to the time of the Dilatation and Contraction of the *Auricle*, and the Beginning of the Contraction of the *Ventricle*, or to the time of the Dilatation and Contraction of the *Ventricle*.

PROP. II.

The time of the filling of the Auricle *is equal to the time of the Contraction of the* Ventricle, *or the Arteries, diminiſh'd by the time of the Dilatation of the* Venticle. I prove it thus:

The

The *Auricle* is full a little before the Contraction of the Arteries is finiſh'd; for the Contraction is not perfectly finiſh'd till they are ſtruck again by the Blood out of the *Ventricle*. But after the *Auricle* is full, the *Ventricle* muſt dilate and contract before the Arteries are ſtruck, that is, before the Interval of their Contraction is finiſh'd. It begins to fill upon the Contraction of the *Ventricle*, and is full a little before the Contraction of the Arteries is finiſh'd: Therefore the time of its filling is equal to the time of the Contraction of the *Ventricle*, or the Interval of a Contraction of the Arteries–the time of the Evaneſcent Contraction of them, that is, the time of its filling is nearly equal to the Interval of a Pulſe.

Of RESPIRATION.

From Dr. *Lower*'s Experiments in his Book *de Corde*, it appears that the Air enters into the Lungs, and from Dr. *Muſgrave*'s Experiment of ſtopping the *Aſpera Arteria* of a large Healthy Dog, that the Blood will no longer circulate thro' the Lungs, than they have Air inſpired to forward the Circulation. And that the Forces of the Heart and Arteries are not ſufficient alone to carry it thro' them. Here is apparent the Perfection of Wiſdom and Art to make the Air neceſſary for the Circulation of the Blood thro' the Lungs. For their only Uſe being to carry Air to all the Parts of the Body, when they are hindred from doing that, by tying the *Aſpera Arteria*, or any other way, the Blood will no longer circulate thro' them, for the Circulation would then be vain and uſeleſs. This is a Mark of the Divine Artiſt not to permit a vain Circulation: So true is that antient Maxim, *God and Nature do nothing in vain.* Hence follows a *Criterion* by which to judge of that Quantity of Air which is neceſſary for the Conſtitution of an Animal. As much Air as is neceſſary for the Conſtitution, is neceſſary for the Circulation of the Blood thro' the Lungs, no more nor no leſs. For if more were neceſſary for the Circulation thro' the Lungs than for the Conſtitution, there would be a ſuperfluous Overplus, which is contrary to the Perfection of Art; if leſs be ſufficient for one than for the other, then indeed the Blood would circulate thro'

thro' the Lungs, but in vain, becauſe they would not convey a ſufficient Quantity of Air into the Blood. Neither of theſe can be. I add, that there is a quick and large Demand for Air in the Human Body. For if there were Air lodged in it ſufficient for any time, the Circulation might be continued in the Lungs without any Irregularity. But we find it is not. The Reaſon is this: The Air in the Blood is ſoon exhauſted and ſpent; if for want of Reſpiration the Lungs have none to carry, to what purpoſe ſhould the Circulation be continued in them. I am of the Opinion, that a great Quantity of *Air* enters into the Compoſition of the *Nerves*, and is ſpent in nouriſhing and repairing the Subſtance of them. And that the Reaſon why ſome

Animals, as the *Tortoiſe*, &c. can live with little or no Air, cloſe and confined, is chiefly becauſe they have few Nerves to be nouriſhed, and thoſe of a different Compoſition from ours: A great Confirmation of this is the Smallneſs of the Head of the *Tortoiſe*, *Viper*, &c. And the Reaſon why the human Body wants ſuch a conſtant and large Supply of Air, is, becauſe they are endued with a great Quantity of Brains and Nerves. Theſe being the Engines of Wit and Thought, the Generality of thoſe, who live in moiſt and foggy Airs are obſerved to be of a dull and ſlow Invention.

Some Reflections *on the foregoing Subjects, with ſome Additions.*

REFLECTION I.

THE firſt Reflection muſt be of courſe upon the Diſtention of the Arteries by the Force of the Heart. And here, Firſt, it may deſervedly appear to ſome no ſmall Difficulty, how it comes to paſs that, ſuppoſing a free Currency of the Fluid thro' the Capillary Veſſels, that there is no ſenſible Pulſe in the Veins. This is a Point which I think may be made ſufficiently clear by the following Conſiderations. The laſt Ramifications of the Arteries, as they are almoſt infinite in Number, ſo their *Tubuli* or Canals are extremely minute, and ſmall. I have been ſurprized to ſee their Number and their Slenderneſs; which I had once an Opportunity of viewing in the *Muſæum* of the Learned Dr. *Frederick Ruyſch* of *Amſterdam*, who perhaps has the beſt Preparations of that kind of any in the World. Hence it muſt follow that the *Globuli* of Blood move with Difficulty thro' theſe inconceivably ſlender Pipes, and that the Fluid there almoſt loſes the Nature of a Fluid. And indeed ſome viewing the Circulation of the Blood with a Microſcope, have obſerved that a *Globule* of Blood paſſing thro' a Canal of this kind, has been compreſſed, but that when it came to a wider part of the Canal, it would re-aſſume its former Figure of a *Sphere* or *Globe*.

Hence it follows, that the Veins are not diſtended by the Pulſe of the Heart. And again, upon the Contraction of the Arteries, the Blood being difficultly and ſlowly puſhed or ſqueezed thro' the Capillaries, comes very ſlowly into the Veins, and then neither for this Reaſon can there ariſe any Diſtention of the Veins. Thus then we have found ſome kind of Obſtacle to the Puſh of the Blood coming out of the Heart into the Arteries, and they muſt of neceſſity be diſtended as we ſee they are.

2. To proceed; From the Conſideration of the Smallneſs of the Force of the Heart may ariſe a juſt Suſpicion that ſome late Calculations concerning the Force of the *Muſcles* employed in *Digeſtion* and *Reſpiration*, are carryed much too high, and I think this might eaſily be demonſtrated; but ſince they are ſo univerſally entertained and applauded by Phyſicians, I ſhall forbear to engage in theſe Matters.

3. Theſe Speculations concerning Diſtentions can hardly fail to put one in mind of the prodigious Force of Stretching. For which Purpoſe the Figure marked with the Letters A G C D F E B at *Prop*. 4. may ſerve. The Weight E B D F is ſuppoſed to ſtretch the Parallelogram A C B D, being ſtretch'd, the Sides A B, C D,

muſt approach nearer to each other; and if in any oppoſite Points between A & B, and between C & D, two little Weights were applyed, they by means of the Weight below would be drawn nearer to each other. Now if that little Weight were applyed to every Point on each ſide, that is, if the Weight on each ſide were equal in Length to each ſide A B C D of the Parallelogram, theſe two Weights would with the ſame Force, and with the ſame Eaſe, be drawn nearer one another, as the two firſt little Weights were; and this would be true, tho' the Sides A B, C D, were never ſo long, and conſequently the *finite* Force at the Bottom might have an *infinite* Effect. Of what Uſe this may be in raiſing and moving vaſt Bodies, I leave to *Mechanicians* to determine.

REFLECTION II.

This ſhall be upon the Dimenſions of the Coats of the Arteries. I find their Thickneſſes to be as their correſpondent Diameters, or which is all one, their Circumferences. This Rule I ſuppoſe to hold in their firſt Formation, and during the time of their Growth, and Nutrition to be perpetually obſerved. And how amazing is that Foreſight and Continuance which has ſo compoſed them, and ſettled the exact and unerring Laws of their Nutrition, that when at any time their Circumferences are grown to double their Length, at the ſame time their Thickneſſes ſhall be doubled too.

REFLECTION III.

Upon the Circulation of the Blood; and here,

1. Since this is ſo famous a Diſcovery, and makes, not without Reaſon, ſo great a Noiſe in the World; I ſhall in a few Words here give the Hiſtory of it, abridged from a late *Treatiſe* of a Learned Author. It muſt be allowed that *Hippocrates* has ſeveral Expreſſions in his Works, on which thoſe who are fond of giving the Glory of all our later Diſcoveries to ſome Antient or other of great Name, may put a favourable Interpretation. Nay, he does ſomewhere ſay, that Veins and Arteries are the Fountains of human Nature, the Rivers that water the whole Body,

that convey Life, and which if they be dryed up, the Man dies: and in another Place he ſpeaks of a kind of Circle, which he ſuppoſes the Blood-Veſſels to make by a Communication with one another: So that he had a confuſed Idea of it, but he could by no means mark out the *Paths* which the Blood went in, in its Circulations, nor did he ever point out ſo much as the Heart to be the great Force which ſent it forwards, and without which it could never be carryed round. In ſhort, the firſt that ever had a diſtinct Notion of this Matter, was *Michael Servetus*, a Spaniſh Phyſician, who was burnt for *Arianiſm* at *Geneva*, about an 150 Years ago. He in a Book of his intituled *Chriſtianiſmi Reſtitutio*, printed in the Year MDLIII.

clearly aſſerts the Paſſage of the Blood thro' the Lungs, from the right to the left *Ventricle* of the Heart.

Realdus Columbus of *Cremona*, was the next that ſaid any thing of it in his Anatomy, printed at *Venice*, 1559. There he aſſerts the ſame Circulation of the Blood thro' the Lungs, which *Servetus* had done before, and is more particular in his Deſcription of it than *Servetus*, and takes notice of the *Valves* of the Heart.

Andreas Cæſalpinus makes yet farther Advances; but ſtill the Matter was ſomewhat in the dark, when an *Engliſh* Gentleman, Dr. *William Harvey*, took it in hand, and with indefatigable Pains traced the viſible Veins and Arteries throughout the Body in their whole Journey from and to the Heart, and by ſo doing, acquired to himſelf immortal Fame. But,

2. After all there remained a Deficiency in the Deſcription of the Times of the opening and ſhutting of the *Auricles* and *Ventricles*, and of the Contraction of the Arteries, which is a Curioſity by no means to be omitted by thoſe who conſider this ſurpriſing Work of Nature. This I have endeavoured to do; and I hope have given ſuch Hints, as with a very little Correction or Addition may repreſent to us diſtinctly all the various Workings of the ſeveral *Engines* of Circulation.

3. The Heart being a Muſcle, and moved by the Inſtrumentality of the *Nerves*; 'tis, I confeſs, very unaccountable, that eſpeci-

ally the Hearts of cold Animals, ſuch as *Eels*, will continue their *Vibrations* or *Pulſations* ſometimes for many Hours after they are ſevered from their Bodies; yea, tho' the *Ventricle* be open'd, and all the Blood ſqueez'd out. Nay, when the Heart has quite ceaſed from Pulſation, it may be excited to beat afreſh by the Application of warm Spittle, or by being prick'd gently with a Pin or Needle. Yet farther, tho' you divide the Heart of an Eel thus ſevered from its Body into three Pieces, each of theſe Pieces will continue their Vibrations, and which is very remarkable, if you ſprinkle Vinegar on one of theſe Portions, that will immediately ceaſe from its Motion, while the other two continue theirs.

4. Whereas I have attributed a peculiar Energy to the left *Auricle*, and it may be judged a Fancy ſo new, and out of the way, as to leave room for great Doubts concerning it; I ſhall here give ſome additional Strength to that Hypotheſis.

In the firſt Beginnings of Generation it appears from the undiſputed, and accurate Obſervations of the diligent and curious *Malpighius*, that what afterwards is formed into a real Heart, is then very different in Shape and Figure, and Structure, from what it afterwards grows to be.

There is at that time a Communication continued from the right *Auricle* by a Canal, to the right *Ventricle*, from the right *Ventricle* a Communication by another Canal to the left *Ventri-*

cle, and from thence into the *Aorta*; and which is very ſurpriſing, no left *Auricle* appears. This Structure of the Heart is by no means fitted for Pulſation; and ſince it can only ſerve for a gentle Fluctuation of ſome thin Fluid thro' thoſe Parts; it is worth obſerving, that in this ſhapeleſs and imperfectly formed Heart, there appears no left *Auricle*. For as if I ſuſpect this Auricle be the primary and leading *Engine* of Pulſation, it is but agreeable to the accurate and perfect Meaſures of the great Divine Artiſt, that it ſhould not appear till the Heart be formed, and fitted in all its other Parts for that Work, for which it is at laſt peculiarly deſigned.

But now as the ſame *Malpighius* informs us within the ſpace of not many Hours. The Supernumerary Canals diſappear, the *Septum* is formed, the right *Auricle* comes cloſe to the right *Ventricle*, and at laſt ſtarts out the left *Auricle*, fix'd in its Place over the left *Ventricle*. The pulmonary Artery and Vein appear, and all things are in a Readineſs for the carrying on the Circulation of the Blood; and then it is, that the maternal Blood is conveyed by proper Ducts to the Heart.

I might proceed to make other Reflections upon other Parts of the preceding Treatiſe, but theſe are all I ſhall now make.

The APPENDIX.

Of PERSPIRATION.

THis Subject has been ſo well handled by *Sanctorius*, in his *Medicina Statica*, and ſo much to the Satisfaction of the learned World, that I ſhall only make a few Remarks upon it: Such as theſe have occurred to my Mind.

'Tis known that a Quantity of nutritive Matter, or Chyle, paſſes out of the Inteſtines into the Lacteals, and into the Blood, and having received a Mixture of Air in its Paſſage thro' the Lungs, is qualified for Nutrition; this in the younger or growing Age I apprehend is thus diſpoſed of. There goes leſs of it off in Perſpiration, than is ſpent in Nutrition; and thus the Parts of the Body increaſe in Bulk and Magnitude. In *virili ætate*, Quantities nearly equal, go off by Perſpiration, and are added in Nutrition, and then Growth is at a ſtand. In the declining Age more goes off by Perſpiration, and other ways, than is added by Nutrition, and then the Body withers and declines; and at this time there being a great

Quantity of *Fluids* diſcharged one way and another, the Oſſification of Griſtles and ſome Parts of the Arteries, &c. does enſue; the Loſs of the Fluids being great, the Parts are left hard and oſſified; ſo that there is a Tendency in the Human Body to become a bony Statue.

This Perſpiration is from almoſt all Parts within, and without, ſo that there ſhould ſeem to be communicating Pores every where within, conducting the perſpirable Matter to thoſe without on the Surface of the Body; and hence poſſibly that Problem may be ſolved, how it comes to paſs, that ſuch as have tender Lungs ſhall cough immediately upon their ſitting on a cold Chair, or the like? But I ſhall conclude what I have to ſay upon this Article,

ticle, by laying down, or propoſing to farther Diſquiſition the two following Aphoriſms.

APHORISM I.

The ſame Matter is both *nutritive* and *perſpirable*. And conſequently,

APHORISM II.

Therefore whatever Matter ceaſes to be *nutritive*, it in a very great meaſure becomes *perſpirable*.

A very remarkable Inſtance of this we have in the Bones; which when they ceaſe to grow, then I conceive that the bony Matter that was wont to nouriſh them, becomes ſuch Matter as ought to be thrown off from the Body and

Blood; and if it be not diſcharged as it ought, I am inclined to think, becomes the Cauſe of the *Rheumatiſm*, and *Gout*. And this I the rather think, becauſe the latter of theſe Diſeaſes ſeldom or never attacks Perſons before they have done growing.

This bony Matter is ſuch, conſiſting of thoſe infinitely ſmall *Laminæ*, of which the Bones are compoſed, that, cutting and tearing the tender Membranes in which 'tis fix'd, it may very well be allowed to produce all the horrible Tortures of a Fit of the Gout. And thoſe chalk Stones (as they call them) which grow in the Joynts of gouty Perſons, look very much like ſuch Stuff as I ſpeak of.

Hence we may be directed in our Cure of the Gout (above all things) by proper Medicines, and Exerciſe, to endeavour to promote a regular and plentiful Perſpiration.

Of the SECRETIONS of the Animal Body.

What follows is part of a Letter written to Dr. Mead *ſome Years ago, and then publiſh'd in the Philoſophical Tranſactions.*

NO one, who has endeavoured to explain the manner by which *Secretions* are performed, ſeems to me to have given a ſatisfactory Account of that Matter, nor do I doubt but that a Man of your Sagacity and Skill in theſe Affairs can diſcover the Defects of the ſeveral Opinions of the Authors concerning them.

I ſhall therefore propoſe my Opinion as briefly as I can.

It ſeems to me that the whole Buſineſs may be reduced to this double Enquiry. 1*ſt*. How a *thin Fluid* (ſuch as is the *Urine*) may be ſeparated from the Maſs of Blood, and the remaining Parts circulate back to the Heart. 2*dly*. How a *thick* or *viſcid Fluid* (ſuch as is the *Bile* or *Semen* for Example) may be ſeparated from the Maſs of Blood, and the other Fluids, both thinner and thicker, than this particular Fluid to be ſeparated, circulate back to the Heart: And that I may be the more plain, I ſhall give a general Idea of the Structure of the *Glands*. A *Gland* I conceive to be compoſed, 1*ſt*. Of the Ramifications of the Blood-veſſels incloſed in a common Membrane, which ſend off ſeveral Fibres, by which theſe minute Veſſels are tied together, and that the Veins are a Continuation of the Arteries. Of this Dr. *Areskin* has fully convinced us by an Injection of Wax in an humane Body, ſo dextrouſly performed, that the Wax being injected by the Arteries, filled the Veins at the ſame time; and afterwards by a curious Diſſection of the Part, where the Continuation of the ſmall Ramifications of the Arteries and Veins did almoſt appear to the naked Eye.

2*dly*, I conceive that when the Branches of the Arteries begin to grow very ſmall, they ſend off ſeveral *Ducts*, whoſe *Orifices* are of different Dimenſions. Theſe *Ducts* are of two ſorts.

The firſt of theſe, which in the ſame Artery are always ſmaller than the ſecond; paſs immediately from the Artery, and open into the Veins.

The ſecond which paſs off nearer to the Extremity of the Arteries unite and carry off a Liquor from the Maſs of Blood for particular Ends in the ſeveral Parts of the Body. It is to be obſerved that in one Caſe the ſecond ſort are only to be found.

I imagine that a *thin Fluid* may be ſecerned from a thick one, when the *Orifices* of the ſecretory *Ducts* are ſo ſmall, as to admit no other but that thin Fluid, and that at the ſame time the remaining Parts of the Blood which are thicker continue their Courſe in the Veſſel.

Again, I imagine that a *thick Fluid* may be ſecerned, when the thinner Parts are carried off ſome other way, ſo that the Liquor to be ſecerned will be the thinneſt of the remaining Maſs.

Upon theſe Principles I think it will be eaſie to explain the Doctrine of *Secretions*. And now in the firſt Place let us examine how the *thinner Secretions* are performed.

As for Inſtance, the *Urine*.

When the Blood by the Contraction of the Heart is puſh'd into the Arteries, they are dilated, which again contracting themſelves, puſh it forward into all the Parts of the Body, and amongſt the reſt into the Ramifications of the Arteries, of which the Glands of the Kidneys are compoſed. By this means the Blood paſſes by the *Orifices* of the Secretory *Ducts*; when theſe Arteries contract themſelves, they preſs the Blood, and force the thinner Parts into the Orifices of thoſe Ducts (which will receive no thicker Fluid) and carry it toward the *Pelvis*, and the remaining part of the Blood into the Veins, by them to be carryed back to the Heart. Thus a thin Liquor may be ſeparated from the Maſs of Blood.

In the ſecond Place let us examine, how a thick Liquor may be ſeparated from the Maſs of Blood where thinner Liquors are mix'd with it.

For inſtance let us take the *Gall* or *Semen*.

When the Blood is puſh'd into the *Cœliac* or Meſenteric Arteries, 'tis forced to paſs into the Glands of the Stomach, Pancreas, Spleen and Inteſtins, &c. where the Liquor *Gaſtricus Succus*, *Pancreaticus*, *Liquor inteſtinalis*, are ſeparated by the above-mentioned Method. The Blood thus robbed of various thin Liquors, is puſh'd on into the Veins, which anſwer to thoſe Arteries, which Veins unite, and form a large Trunk called the *Vena Porta*, which entring into the Subſtance of the Liver, by its ſmall Ramifications chiefly forms the *Glands* of which the *Liver* is compoſed. Here again all the Fluids contained in the *Vena Porta*, which are thinner than the *Bile*, are ſeparated from the Maſs of Blood by the firſt ſort of ſecretory Ducts (which we ſaid opened into the Veins) and there are diſcharged and mix'd with the Blood, which is paſſing towards the Heart. At the ſame time the Bile with the reſt of the Blood, which is thicker, continues its Courſe; now all the thin Liquors being ſeparated, the Bile is the thinneſt part of this Maſs of Blood, and ſo may be received by excretory Ducts capable of receiving it, and no other.

The *Semen* being a very thick Liquor, is ſeparated much after the ſame manner, *viz.* The Blood being puſh'd into the *ſpermatick Arteries* paſſes into the Subſtance of the *Teſticles*, where all the Liquors that are thinner than that, out of which the *Se-*

men is to be taken, are ſeparated by the firſt ſort of Secretory Ducts, and carried back to the Maſs of Blood. Then this *Liquor Seminalis* being the thinneſt of the remaining Maſs, is ſeparated by excretory Ducts capable to receive that and no other. After the *Liquor Seminalis* is ſeparated from the Maſs of Blood by the aforeſaid Method, it is puſh'd forward into the Excretory Ducts, where there are other Ducts which take their Origin all along from them, which Ducts are capable to receive the thinneſt Parts of the *Liquor Seminalis*, and convey them to the Maſs of Blood, and thus the *Semen* is left behind to paſs into the *Vas deferens*.

And 'tis worth remarking, as the *Semen* grows thicker by continual Separations, that the Canal in which it runs grows larger and larger, as appears by the Structure of the *Teſticles*, *Epididymis* and *Vas deferens*. Hence we may give a true Account why the Canals of which the *Teſticles* are compoſed are ſo long, *viz.* That there might be time enough to ſeparate all the thin Fluids.

By this Method we ſee how the thickeſt and thinneſt Fluids may be ſeparated from the Maſs of Blood. And how intermediate Liquors may be ſeparated by Canals adapted to receive them.

Thus in a word the whole Doctrine of *Secretions* may be reduced to this.

To ſeparate a Liquor of any determinate Thickneſs, all the Fluids which are thinner muſt be carried off by ſmall Canals, and the Liquor to be ſeparated, being the thinneſt of the remaining Maſs, is ſecerned, becauſe the Ducts are capable to receive it, and no other.

COROLLARIES.

I.

Hence the Uſe of the *Spleen* is evident, which till this time was in vain enquired for by Anatomiſts.

II.

Hence appear the Origin and Uſe of the *Lymphaticks*.

III.

Hence the Texture of many *minute Parts* of the Body may be diſcovered.

You know, Sir, of how great Moment ſuch Conſiderations as theſe are to the Knowledge both of the Cauſes and Cure of many Diſtempers; having already in ſome degree convinced thoſe who are the only capable Judges of theſe Matters, that *Mechanical Enquiries* into the *Animal Oeconomy*, are the beſt Foundation upon which we can ſafely proceed in the Practice of *Phyſick*.

MVSEVM
BRITAN
NICVM

FINIS.